ELECTRONIC DEVICES WITH CARBON NANOTUBE PRINTED CIRCUITS

BACKGROUND

This relates generally to electronic devices and, more particularly, to structures such as printed circuits for electronic devices.

Printed circuits are often used to route signals within electronic devices such as cellular telephones, computers, and other electronic equipment. Electrical components can be mounted to a printed circuit using solder. Because printed circuits are relatively thin, the use of printed circuits to route signals between components in an electronic device can help minimize the size and weight of the device.

In some situations, it can be difficult to satisfactorily mount printed circuits within an electronic device. Flexible printed circuits often have bends and can be subjected to numerous bending and unbending cycles during operation of a device. If care is not taken, a flexible printed circuit will be bent too much. This can lead to cracks in signal lines on the flexible printed circuit and poor reliability. Although cracks can be reduced and reliability enhanced by placing restrictions on the amount of bending that is imposed on a flexible printed circuit, this can create undesired bulk and undesired limitations on the movement of the flexible printed circuit.

It would therefore be desirable to be able to provide improved structures such as printed circuits for electronic devices.

SUMMARY

An electronic device has structures such as substrates and internal housing structures. The substrates may include rigid substrates such as rigid printed circuit boards and flexible substrates such as flexible printed circuits, flexible touch sensor substrates, and flexible display substrates. The internal housing structures may include a carbon nanotube midplate that extends between opposing housing walls to lend structural support to an electronic device.

Carbon nanotubes may be patterned to form carbon nanotube signal paths on the substrates. The signal paths may resist cracking when bent. A bent portion of a carbon nanotube signal path may be formed in a portion of a flexible substrate that traverses a hinge or other flexible portion of an electronic device.

A flexible structure such as a flexible printed circuit may have a carbon nanotube layer interposed between polymer layers. The carbon nanotube layer may be patterned to form carbon nanotube signal paths that are covered by a polymer layer. Openings in the polymer layer may be formed to expose metal solder pads on the carbon nanotube signal paths.

A stiffener may be attached to the flexible printed circuit with adhesive under the metal solder pads. Polymer materials in the flexible structure may be molded to form bends. Bends may be formed along edges of a touch sensor or display, may be formed in a flexible printed circuit, or may be formed within other carbon nanotube flexible substrate structures.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of an illustrative electronic device in accordance with an embodiment.

FIG. **2** is a perspective view of an illustrative electronic device that bends along a flexible portion such as a flexible seam associated with a hinge in accordance with an embodiment.

FIG. **3** is a cross-sectional side view of an illustrative electronic device having a flexible printed circuit with a bend in accordance with an embodiment.

FIG. **4** is a cross-sectional side view of an illustrative electronic device having a display such as a touch sensor display with a bend in accordance with an embodiment.

FIG. **5** is a cross-sectional side view of an illustrative carbon nanotube layer in which carbon nanotubes are being supported by a substrate in accordance with an embodiment.

FIG. **6** is a cross-sectional side view of an illustrative carbon nanotube layer in which a layer of carbon nanotubes and a metal layer or other layer has been formed on a substrate in accordance with an embodiment.

FIG. **7** is a cross-sectional side view of an illustrative carbon nanotube layer in which a layer of adhesive on a substrate has been used to attach a layer of carbon nanotubes to the substrate in accordance with an embodiment.

FIG. **8** is a cross-sectional side view of an illustrative carbon nanotube layer in which carbon nanotubes have been embedded in a matrix such as a polymer binder in accordance with an embodiment.

FIG. **9** is a diagram of illustrative equipment involved in forming carbon nanotube structures for an electronic device in accordance with an embodiment.

FIG. **10** is a diagram of illustrative operations and equipment involved in forming carbon nanotube structures for a flexible substrate such as a flexible printed circuit in accordance with an embodiment.

FIGS. **11**A, **11**B, **11**C, **11**D, and **11**E are perspective views of an illustrative printed circuit with carbon nanotubes during various phases of fabrication in accordance with an embodiment.

FIG. **12** is a cross-sectional side view of an illustrative carbon nanotube printed circuit with a stiffener in accordance with an embodiment.

FIG. **13** is a flow chart of illustrative steps involved in forming carbon nanotube structures such as carbon nanotube printed circuits in accordance with an embodiment.

FIG. **14** is a side view of illustrative roller-based equipment for laminating layers together for a carbon nanotube printed circuit in accordance with an embodiment.

FIG. **15** is a side view of illustrative stamping equipment such as roller-based stamping equipment of the type that may be used to form carbon nanotube structures in accordance with an embodiment.

FIG. **16** is a cross-sectional side view of an illustrative carbon nanotube structure during molding and bending operations in accordance with an embodiment.

FIG. **17** is a perspective view of an illustrative carbon nanotube structure with a right-angle bend in accordance with an embodiment.

FIG. **18** is a cross-sectional side view of an illustrative carbon nanotube structure coupled to another structure using conductive material in accordance with an embodiment.

FIG. **19** is a cross-sectional side view of an illustrative electronic device that has a structural housing member such as a midplate member formed from carbon fiber material in accordance with an embodiment.

DETAILED DESCRIPTION

Electronic devices may be provided with carbon nanotube structures or other structures based on carbon (e.g., graphene